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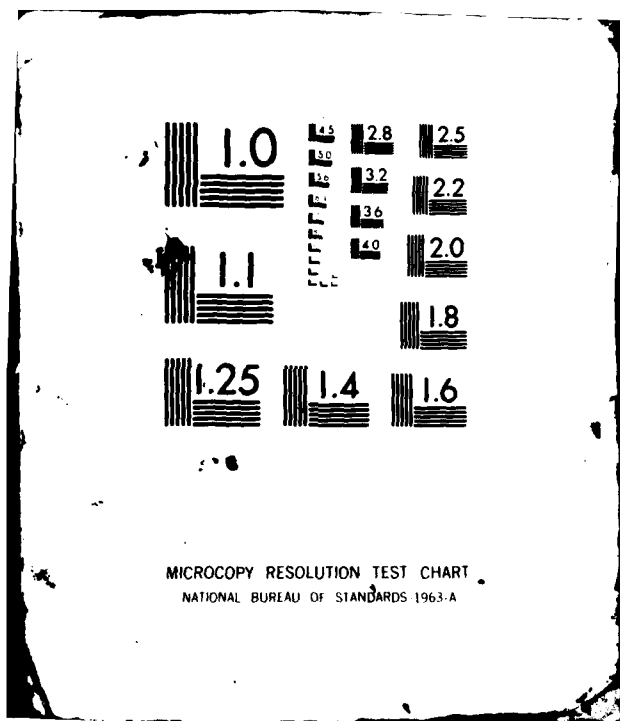
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Electronic Properties of Heterojunctions

Work under this contract was primarily concerned with experiments on so-called lattice-matched Schottky barrier interfaces and with theory of superlattices. These are both rather idealized cases of semiconductor interfaces, simplifying some of the complexities of the general interfaces and affording new insights.



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Experiments on Lattice-Matched Schottky Barriers

Many of the complexities of the usual Schottky barrier, e.g. Au deposited on GaAs, are absent in the *lattice-matched* Schottky. Whereas the former interface is bounded by materials to either side that are very different structurally and electronically, in the lattice-matched case the bounding materials are relatively similar, allowing a simpler application of theoretical ideas. The first experiments on lattice-matched Schottky barriers were performed under this contract. In many respects these experiments followed naturally from work on the "common-anion" rule for Schottky barrier heights, performed under a preceding Office of Naval Research contract and thus represent an extension of that earlier work.

A main result of these experiments was the discovery of a substantial (~ 0.3 eV) stoichiometric influence on Schottky barrier height in CdTe-based systems. The magnitude of this effect is $\sim 6\times$ that previously known (in III V compounds). Also discovered in the present experiments were methods to make higher barriers on various n-semiconductors than was previously possible. Nevertheless, the barrier heights obtained in the important CdTe/HgTe test case were not as high as would be predicted by various theories. A proposal was made for this discrepancy based on properties of semiconductor inversion layers, and which may be testable in MBE-fabricated structures likely to be built in the next two years. A further result of the present experiments was the development of new CVD techniques to fabricate Schottky interfaces, a development

that is influencing contemporary CdTe-based device technology.

Three students, much of whose support was provided by this contract, contributed to this work. R. A. Scranton, after completing his Ph.D. here, has been a member of the technical staff at I.B.M., T. J. Watson Research Center. John S. Best, who was also an N.S.F. graduate fellow, completed his Ph.D. here and has since been a member of technical staff at I.B.M. San Jose Research Center. T. F. Kuech completed his Ph.D. here and started at I.B.M., T. J. Watson Research Center late in 1981, where he is continuing C.V.D. methods mentioned above to fabricate semiconductor structures.

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2. "The Semiconductor-Conductor Interface", J. O. McCaldin and T. C. McGill, in Thin Films - Interdiffusion and Reactions, edited by J. M. Poate, K. N. Tu, and J. W. Mayer, (John Wiley & Sons, Inc., New York, 1978), p. 69.
3. "Dissolution of Amorphous Silicon into Solid Aluminum", R. A. Scranton and J. O. McCaldin, J. Vac. Sci. Technol. 15, 1358 (1978).
4. "Lattice-Matched Heterostructures as Schottky Barriers: HgSe/CdSe", J. S. Best and J. O. McCaldin, J. Vac. Sci. Technol. 16, 1130 (1979).
5. "The Schottky-Barrier Height of Au on $n\text{-Ga}_{1-x}\text{Al}_x\text{As}$ as a Function of AlAs Content", J. S. Best, Appl. Phys. Lett. 34, 522 (1979).
6. "Compositional Dependence of Schottky Barrier Heights for Au on Chemically Etched $\text{In}_x\text{Ga}_{1-x}\text{P}$ Surfaces", T. F. Kuech and J. O. McCaldin, J. Vac. Sci. Technol. 17, 891 (1980).
7. "The Metal-Semiconductor Interface", J. O. McCaldin and T. C. McGill, Ann. Rev. Mater. Sci. 10, 65 (1980).
8. "Low Temperature CVD Growth of Epitaxial HgTe on CdTe", T. F. Kuech and J. O. McCaldin, J. of The Electrochemical Soc. 128, 1142 (1981).

9. "The Use of Au-Cd Alloys to Achieve Large Schottky Barrier Heights on CdTe", Thomas F. Kuech, J. Appl. Phys. 52, 4874 (1981).
10. "Epitaxial Growth of Ge on <100> Si by a Simple Chemical Vapor Deposition Technique", T. F. Kuech, M. Mäenpää, and S. S. Lau, Appl. Phys. Lett. 39, 245 (1981).
11. "The Heteroepitaxy of Ge on Si: A Comparison of Chemical Vapor and Vacuum Deposited Layers", M. Mäenpää, T. F. Kuech, M-A. Nicolet, S. S. Lau, and D. K. Sadana, J. Appl. Phys. 53, 1076 (1982).
12. "HgTe/CdTe Heterojunctions: A Lattice-Matched Schottky Barrier Structure", T. F. Kuech and J. O. McCaldin, J. Appl. Phys. (to be published about May 1982).

Theory of Superlattices

Superlattices offer the opportunity of preparing man-made structures with properties that are substantially different from naturally occurring materials. Work partially supported under this contract included some of the first studies of the electronic band structure of these systems.

The principal result is the first treatment of the GaAs-AlAs band structure for different superlattices. These results showed that the band gap could be varied from that of GaAs to approximately the value of the comparable GaAlAs alloy. The electronic spectra as a function of layer thickness was predicted. The theoretical work on the superlattice band structure started a whole series of theoretical and experimental studies of superlattices.

The support provided by this contract supported in part the research work of J. N. Schulman. After completing his Ph.D. here and spending a year at the University of Illinois in the solid state theory group, he is now an assistant professor of physics at the University of Hawaii where he has initiated a research program in the physics of superlattices.

Publications

1. J. N. Schulman and T. C. McGill, Phys. Rev. Lett. 39, 1680 (1977).
2. J. N. Schulman and T. C. McGill, Phys. Rev. 19, 6341 (1979).